

Using Hyperdocuments for Knowledge Management: An Encyclopedia of Southern Appalachian Forest Ecosystems

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Abstract-- Land managers increasingly need improved access to research knowledge that is thoroughly organized, condensed, and presented in a form that is useful for problem solving. In this paper, we describe the application of hyperdocuments for knowledge management, using an example of a newly developed hypertext encyclopedia on the southern Appalachians. The Encyclopedia of Southern Appalachian Forest Ecosystems (www.iesaf.srs.fed.us) makes research knowledge of southern Appalachians hardwood forests more accessible and more understandable to users. The Encyclopedia synthesizes and integrates the past 65 years of research on southern Appalachian upland ecosystems in a hyperdocument-based encyclopedia system accessible over the Internet. The Encyclopedia is more than a Web site, because it incorporates "intelligent" tools that enhance the use and navigation of the encyclopedia and allow it accommodate users of various skill levels and interests.

INTRODUCTION

Oak is a major component of several predominant forest cover types in the southern Appalachians. Many social and economic institutions in this region depend on the variety of benefits afforded by upland oak forests, such as abundant, high-quality timber; plentiful and varied wildlife; extensive recreational opportunities; and, a diversity of special forest products.

Socioeconomic concerns for oak cover types have driven substantial research efforts in the southern Appalachians. As a result, an overwhelming body of information exists covering many aspects of upland oak ecosystems in these mountainous areas. For example, the Coweeta Hydrologic Laboratory has produced nearly 900 publications. Bent Creek Experimental Forest has produced over 287 publications. The Southern Appalachian Assessment (SAA) generated nearly 3 GB of information about the status of resources in the southern Appalachians (SAMAB 1996a,b, c, d, e). A recent search of AGRICOLA for keywords "southern <and> Appalachian" identified 996 articles and books published since 1979.

Despite the accumulation of this large body of research knowledge, a huge gap exists between what scientists know and what the management community is able to apply on the ground. Most research knowledge is neither easily accessible nor readily useable because it has not been synthesized and integrated into a coherent, meaningful knowledge structure. In most cases, this knowledge-base retains the fragmented nature of the many separate publications that compose it. Consequently, what should emerge as an integrated and coherent body of knowledge appears instead to managers as disconnected pieces of the "whole" that they need for applied problem solving. The current poorly organized system of information almost guarantees that knowledge is lost, misplaced, and continually recreated.

Because land managers deal with forest resources in aggregate, they need knowledge that captures the integrative nature of ecosystems and management. Moreover, as natural resource management moves from a difficult multiple-resource management paradigm to an even more difficult ecosystem management paradigm, the need for better and more powerful knowledge management aids becomes urgent.

Hyperdocument technology provides the power to develop organized and compressed knowledge-bases, thereby improving the speed and accuracy with which data, information, and knowledge are managed. In this paper, we describe the application of hyperdocuments for knowledge management, using an example of a newly developed hypertext encyclopedia on the southern Appalachians. The Encyclopedia of Southern Appalachian Forest Ecosystems (www.iesaf.srs.fed.us) makes research knowledge of southern Appalachians hardwood forests more accessible and more understandable to users. The Encyclopedia synthesizes and integrates the past 65 years of research on southern Appalachian upland ecosystems in a hyperdocument-based encyclopedia system accessible over the Internet. The Encyclopedia is more than a Web site, because it incorporates "intelligent" tools that enhance the use and navigation of the encyclopedia and allow it accommodate users of various skill levels and interests.

Using Hypertext For Knowledge Management

The better we understand how to create, organize, manage, and deliver knowledge, the more efficient we will be as producers, distributors, and consumers of knowledge (McRoberts and others 1991). This recognition of knowledge management's importance has elevated it to the stature of a scientific endeavor—informatics, the science that is concerned with the gathering, manipulation, classification, storage, and retrieval of recorded knowledge.

Knowledge structuring is a fundamental process in knowledge management (Burke 1985). Structuring knowledge means assimilating research results into an organized body of knowledge (Schmoldt and Rauscher 1994). This activity demands creative synthesis and results in a significant compaction of information. However, in most natural language text documents used today, the structure of the subject is more or less hidden, camouflaged by the sequential nature of the medium and the need to gracefully and carefully transition from one idea to the next so the reader can understand the author's meaning. With some notable exceptions (such as encyclopedias), structure in natural language text documents is subservient to the content of the material being presented.

Several technological developments offer vast opportunities for improving the way we manage knowledge: (1) the electronic computer (ca. 1942-present), (2) knowledge-based systems (ca. 1956-present), (3) hypertext concepts and software (ca. 1960-present), and (4) the Internet telecommunications system (ca. 1986-present) (Gehl and Douglas 1999, Schmoldt and Rauscher 1994).

Anyone who has accessed the World Wide Web has been exposed to hyperdocuments—a highly nonlinear and interactive mixture of text, graphics, images, video, and audio. Abstractly, a hyperdocument consists of a network of chunks (or pages—organized collections of information that are each internally self-contained and independently understandable) connected by links (an electronic cross-reference used to connect logically related chunks). Links simulate the mental association between chunks in the mind of the author (Rauscher 1994). In contrast to natural language text documents, hypertext forces the author to explicitly highlight the structure (outline or concept map) first and foremost for the user. Only secondarily, is the user exposed to the content matter.

Hypertext has many advantages that make it well suited for creating and publishing most types of documents, including it can be easily accessed, it occupies little physical space, and it can be published cheaply and rapidly. And, unlike linear print media that is static and assumes a single, fixed skill level by the intended audience, hyperdocuments can be easily updated and manipulated to fit a variety of users.

There are several examples of hypertext knowledge management systems, including: the Encyclopedia of AI Applications to Forest Science (Rauscher 1991), the Ecology and Management of Aspen (Rauscher and others 1995a), the Northeast Decision Model Design Document (Rauscher and others 1995b), A Hypermedia Reference System to the Forest Ecosystem Management Assessment Team Report and Some Related Publications (Reynolds and others 1995), and Oak Regeneration: A Knowledge Synthesis (Rauscher and others 1997).

HYPERDOCUMENT DEVELOPMENT

Producing a hyperdocument is a mixture of the planning required for a software project and that required for writing a book. The following methods were used to create the Encyclopedia of Southern Appalachian Forest Ecosystems.

Identifying Scope And Assembling Material

The first step in developing the Encyclopedia was to precisely identify its scope. We focused on southern Appalachian forest types that have oak as a major component—mixed mesophytic hardwood, oak, and mixed pine-hardwood forest—these constitute 75% of the forest land in the southern Appalachians. We also included additional ecological and socioeconomic topics directly or indirectly related to forest management (Table 1).

After identifying these topic areas, we assembled source material for each area. We focused primarily on secondary literature (review articles, monographs, and textbooks) because it generally offers an organized synthesis of useful knowledge gleaned from the primary literature. Wherever possible, we asked various experts to identify important pieces of secondary literature. Once collected, this source material was scanned to create electronic versions using optimal character recognition software (OmniPage Pro 10®).

Identify Knowledge Content And Structure

The next step in the Encyclopedia's development was to design a comprehensive

outline for the entire hyperdocument. We used Frontpage®, an HTML editor, which offers a convenient navigational view ideal for constructing the hyperdocument's structure. Using this outline in Frontpage®, paragraphs from the electronic versions of source documents were unceremoniously dumped into appropriate pages until all paragraphs of all source material had been "paged."

Writing And Editing Pages

After the paging process, each page in the hyperdocument contained numerous paragraphs from different source material roughly covering the same subject matter. Hypertext authors then organized this disparate material, synthesized the main ideas and wrote an original summary with appropriate citations from the original literature source.

An important concept that was considered when writing these pages was that, since a reader can arrive at a particular location in the hyperdocument from many different directions, the author could no longer rely on sequential reading to present material. Each page of the hyperdocument was written to be independently understandable, much as we demand that journal figures and tables be self-contained. Also, recommended hyperdocument guidelines strongly suggest that no more than 3-5 screens of information be contained in a single page. Therefore, if a hyperdocument page resulted in more than 3-5 screens of material, it was split along logical lines into more detailed sub-pages.

Several additional writing guidelines were used to ensure readers could comprehend these content pages quickly and easily. For example, each page was given a descriptive title, section headings and significant text was in put into bold, and bulleted lists were used wherever possible. Finally, all pages were formatted so that they had a uniform look and feel.

Constructing Navigational Tools

The single greatest difficulty of hyperdocument users is navigating to find desired information without getting disoriented. The navigation problem can be alleviated if authors pay careful attention to navigation devices. We incorporated the following navigational systems and aids into the Encyclopedia.

- Global navigation system: Global navigation aids allow readers (a) to determine their present location, (b) to have some idea of that location's relation to other materials, (c) to return to their starting point, and (d) to explore materials not directly linked to those in which they presently find themselves. The Encyclopedia uses a linked collapsible menu as its primary global navigational tool (present in the left frame of Figure 1). Contents can be browsed through and linked to through this collapsible menu. Other examples of global navigational aids that are used in the Encyclopedia are: table of contents, full text search tools, and figure and table indices.
- Local navigation system: Local navigation aids provide the user with access to knowledge chunks that have some logical relationship with the current chunk. Hyperlinks within the content pages make up the local navigation system. These links can be used to move sequentially within a

subject area. Cross-links embedded within the text can be used to move laterally within the encyclopedia to related topics.

- Intelligent navigational aids: Intelligent navigation aids attempt to help the user select a path through the hyperdocument that is tailored for a particular use at a particular time. This means that the aids are constructed uniquely for each user each time that user enters the hyperdocument. They are not pre-stored in the system. As the hyperdocument is updated, the machine-generated navigation aids will automatically include these updates in their outlines, maps, or diagrams. Currently, intelligent navigational aids are being developed for the encyclopedia that will help users select paths through the hyperdocument.

Evaluation And Verification

Evaluation and verification of the Encyclopedia began as soon as a prototype was available, and will continue throughout the entire development phase. This step is important in ensuring link consistency and correcting global and local navigational problems. Three types of people are involved in this process: 1) copy editors, 2) subject matter experts for content accuracy, and 3) representatives of the target audience to verify ease of use and clarity.

CONCLUSIONS

The Encyclopedia of Southern Appalachian Forest Ecosystems constitutes a framework for organizing what knowledge currently exists on southern Appalachian forests and for improving access to that knowledge. It provides a core knowledge management aid for private landowners and professional forest managers in the region. The most expensive part of creating any such product is the synthesis and organization of the available data, information, and knowledge. This hypermedia core, then, lends itself to numerous uses including its use as the source document for other, more traditional, synthesis products, such as manuals, review papers, and reports. Because our needs in southern Appalachian ecosystem management are not unique, the concepts and techniques developed in this encyclopedia project could be broadly applied to other knowledge application needs in other land management disciplines.

Often where knowledge exists as distinct and narrowly focused publications, knowledge gaps are not easily identified, important knowledge developed a decade or more in the past is unknown, and the interesting, but relatively unimportant, research problems cannot be distinguished from those that are both interesting and critically important. The process we've outlined of synthesizing and integrating knowledge from diverse sources will enable us to better evaluate what knowledge does not exist—where the gaps in our understanding are. Therefore, we also view the resulting product as an aid to scientific investigation, in addition to its role as managers' tool.

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Table 1. Topics included in version 1.0 of the Encyclopedia of Southern Appalachian Forest Ecosystems (www.iesaf.srs.fed.us).

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|--|---|
| <ul style="list-style-type: none"> - Site quality evaluation and classification - Predicting and modeling hardwood regeneration - Concepts of silviculture - Oak ecology and management - Yellow-poplar ecology and management - Silvics of other hardwood species - Managing low-quality stands - Alternative silvicultural systems - Methods and effects of prescribed burning - Timber harvesting and use - Timber supply and demand - Decision making in forest management | <ul style="list-style-type: none"> - Forest insects and diseases - Air quality, water quality - Ecology and management of aquatic resources - Ecology and management of wildlife - Non-timber forest products - Biogeochemical cycles - Disturbance types and successional processes - Wilderness and roadless areas - Recreational supply, demand, and impacts - Threatened and endangered species - Old-growth forests - Biodiversity |
|--|---|

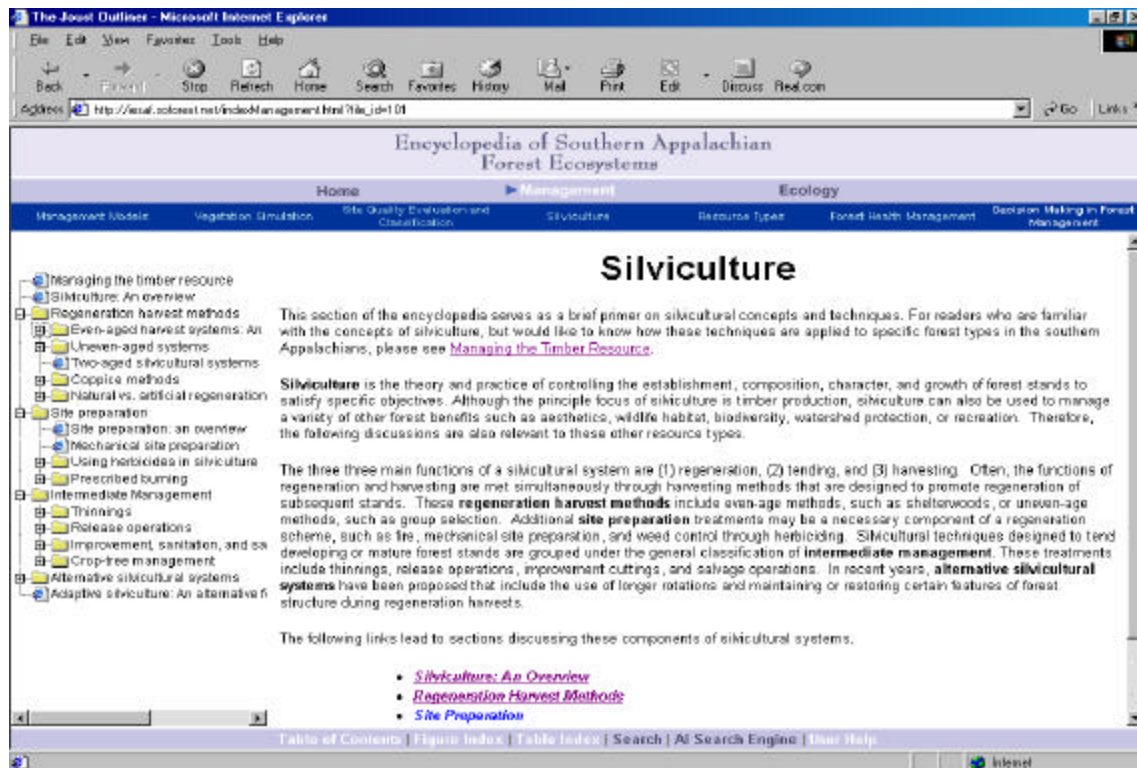


Figure 1. A sample display from the existing "Encyclopedia of Southern Appalachian Forest Ecosystems" showing the introductory page for the silviculture section to be found on the Internet at (http://iesaf.srs.fed.us/indexManagement.html?file_id=101).